

## CLAIMS

What is claimed is:

1 1. An optical encoder sensor head for use with a reflective multi-  
2 track encoder scale, comprising:

3 a quasi-monochromatic light source disposed on a surface of  
4 a planar substrate facing the encoder scale;

5 a plurality of optical detectors disposed on the surface of  
6 the substrate at respective locations defining respective optical  
7 paths between the optical detectors and respective tracks of the  
8 encoder scale; and

9 an optical wavefront dividing element disposed between the  
10 substrate and the encoder scale, the optical wavefront dividing  
11 element being operative to divide an incident light beam produced  
12 by the light source into a plurality of diffracted light beams,  
13 each diffracted light beam being directed toward a respective  
14 track of the encoder scale at a respective angle so as to be  
15 reflected from the respective track along the optical path to the  
16 respective detector.

1 2. An optical encoder sensor head according to claim 1, wherein  
2 the quasi-monochromatic light source comprises a vertical cavity  
3 surface emitting laser (VCSEL).

1 3. An optical encoder sensor head according to claim 1, wherein  
2 the quasi-monochromatic light source emits an expanding cone of  
3 light.

1 4. An optical encoder sensor head according to claim 1, wherein  
2 the plurality of optical detectors includes two optical detectors  
3 disposed on opposite sides of the light source.

1 5. An optical encoder sensor head according to claim 1, wherein  
2 the substrate is a first substrate, and wherein the wavefront  
3 dividing element comprises a diffractive optical element (DOE)  
4 disposed on a second substrate.

1 6. An optical encoder sensor head according to claim 5, wherein  
2 the DOE comprises a layer of material having a thickness selected  
3 to introduce a substantially half-wave delay in light passing  
4 through the DOE.

1 7. An optical encoder sensor head according to claim 5, wherein  
2 the DOE comprises a grating having a square wave profile.

1 8. An optical encoder sensor head according to claim 5, wherein  
2 the DOE comprises a grating having a triangle wave profile.

1 9. An optical encoder sensor head according to claim 5, wherein  
2 the DOE comprises a grating having a sine wave profile.

1 10. An optical encoder sensor head according to claim 5, wherein  
2 the second substrate further includes a plurality of windows, each  
3 window lying along a corresponding one of the optical paths  
4 between the tracks on the encoder scale and the detectors.

1 11. An optical encoder sensor head according to claim 5, wherein  
2 the second substrate comprises a substantially optically  
3 transparent material having a low coefficient of thermal  
4 expansion.

1 12. An optical encoder sensor head according to claim 5, wherein  
2 the second substrate is coated with optically transparent material  
3 having an index of refraction  $n$  different from that of air.

1 13. An optical encoder sensor head according to claim 12, wherein  
2 the optically transparent material comprises a dielectric  
3 material.

1 14. An optical encoder sensor head according to claim 13, wherein  
2 the dielectric material has a refractive index close to the  
3 refractive index of the second substrate.

1 15. An optical encoder including:

2 a sensor head including a substrate and beam divider, the  
3 beam divider including an optical wavefront dividing element, the  
4 substrate having a light source and first and second optical  
5 detectors disposed thereon;

6 an encoder scale including first and second tracks, the  
7 encoder scale being disposed opposite the sensor head with the  
8 beam divider disposed therebetween such that a light beam emitted  
9 by the light source is incident on the wavefront dividing element,  
10 the wavefront dividing element being operative to divide the  
11 incident beam into first and second beams being substantially  
12 incident on the first and second tracks of the encoder scale  
13 respectively, light from the first beam being reflected and  
14 diffracted by the first track to the first optical detector, and  
15 light from the second beam being reflected and diffracted by the  
16 second track to the second optical detector; and

17 a signal processor operative to interpret signals from the  
18 first and second detectors.

1 16. An optical encoder including:  
2 a sensor head including a substrate having a light source  
3 and first and second optical detectors disposed thereon;  
4 an encoder scale including first and second tracks; and  
5 a wavefront dividing element disposed between the sensor  
6 head and the encoder scale, the wavefront dividing element being  
7 operative to divide an incident light beam emitted by the light  
8 source into first and second beams, the first beam being incident  
9 on the first track of the encoder scale, the second beam being  
10 incident on the second track of the encoder scale, light from the  
11 first beam being reflected and diffracted by the first track to  
12 the first optical detector, light from the second beam being  
13 reflected and diffracted by the second track to the second optical  
14 detector.

1 17. An encoder according to claim 16, wherein the wavefront  
2 dividing element is disposed on a substrate of the beam divider  
3 disposed between sensor head and the encoder scale.

1 18. An encoder according to claim 17, wherein the substrate of  
2 the beam divider is fixed relative to the substrate of the sensor  
3 head.

1 19. An encoder according to claim 17, wherein the substrate of  
2 the beam divider and the substrate of the sensor head are fixed  
3 into a single monolithic construction.

1 20. A sensor head for use in an optical encoder, the encoder  
2 including a scale, the scale being movable relative to the sensor  
3 head along a first axis, a distance between the scale and the  
4 sensor head as measured in a direction substantially  
5 perpendicular to the first axis being substantially constant, the

6 encoder generating a signal representative of a position of the  
7 scale relative to the sensor head, the scale including a first  
8 track and a second track, the sensor head comprising a substrate,  
9 a light source, a first optical detector, a second optical  
10 detector, and a beam divider including an optical wavefront  
11 dividing element, the light source being disposed on the  
12 substrate, the first and second optical detectors being disposed  
13 on the substrate, the beam divider being spaced apart from and  
14 fixed relative to the substrate, an emitted light beam emitted  
15 from the light source being incident on the wavefront dividing  
16 element, the wavefront dividing element dividing the emitted  
17 light beam into a first light beam and a second light beam, the  
18 first light beam being incident on the first track, the second  
19 light beam being incident on the second track, light diffracted  
20 from the first track being incident on the first optical  
21 detector, light diffracted from the second track being incident  
22 on the second optical detector.